The Story of a Prairie Restoration Project that Launched a STEM School into Outdoor Learning

Margaret Gorby[1], Kurtz Miller[2], Samuel Eckhart[3], Leanne Jablonski, Ph.D.[4], Don Geiger, Ph.D. [4], Michele Banker[4], Mary McKnight[1], Sharon Goins[1], and David Lawrence[5]

[1]Thurgood Marshall STEM High School, Dayton Public Schools, Dayton, Ohio

[2]Department of Educational Leadership, Miami University, Oxford, Ohio

[3]Xenia High School, Xenia City Schools, Xenia, Ohio

[4]Marianist Environmental Education Center (MEEC), Dayton, Ohio

[5]Jobs for the Future (JFF) Foundation

PRAIRIE GARDEN PROJECT

Introduction

During the 2013-2014 school year, senior environmental capstone became a new course offering at Thurgood Marshall STEM High School, Dayton Public Schools, Dayton, Ohio. The purpose of the course was to provide senior students with an opportunity to participate in standards-based, environmental, outdoor learning with a focus upon the natural history of the Miami Valley. This article will describe the instructional unit about native grass prairies and the subsequent outdoor-learning project of planting a prairie garden behind the high school. The project helped to connect students with nature to highlight the joys of being outside as well as help to address so-called “nature-deficit disorder” [a theory proposed by Richard Louv that students are disconnected from nature and need to reestablish this important link to remain healthy] (Louv, 2008). Over the past five school years, this prairie garden project initiated a whole series of integrated, STEM curriculum units across multiple subject areas, which have been centered on environmental, outdoor learning themes. The first purpose of the article is to tell the story of how a building-based curriculum team collaborated with external environmental education stakeholders to develop an outdoor learning unit about native grass prairies. A second purpose is to provide teachers and curriculum teams with guidance, ideas, recommendations, and resources to initiate similar or more focused types of outdoor learning projects (Appendixes C, D, & E).

Experiences in Nature

Research indicates that many students in America struggle with what has been termed "nature-deficit disorder" (Louv, 2008), which has major implications for students' overall health and well-being. With the right administrative, community, and teacher support, schools can better connect students to authentic outdoor learning experiences, which may help to improve students' mental, physical and spiritual health (Louv, 2012). Outdoor experiences are much needed, especially in high-needs, underserved, urban populations, where interactions with nature may be rare. Outdoor learning has been shown to impact student achievement, including ". . . improved standardized test scores and grade-point averages; and developed skills in problem solving, critical thinking, and decision making (Liberman, 2013, p. viii)." Early conversations between members of the curriculum team in conjunction with survey data suggested Thurgood Marshall STEM High School students typically did not have opportunities to engage in outdoor learning; many students have had a relatively small number of experiences working outside (Teacher #1, Post-Survey; Teacher #3, Post-Survey). Teacher #1 remarked in the post-survey, "[Senior environmental capstone] students [came] from an urban environment and had most[ly] not engaged in garden-type activities [before]" (Teacher #1, Post-Survey). Although this project provided a senior environmental capstone group of students the opportunity to work outdoors, additional outdoor learning experiences followed in later school years.

Literature Review

Since Richard Louv's first edition of *Last Child in the Woods* was published in 2005, multiple societal elements have become united to promote the expansion of outdoor learning in K-12 schools (Broda, 2011). Since the mid-2000s there has been a concerted, nationwide effort to encourage formal and informal educators to provide authentic, outdoor learning experiences to students outside the framework of traditional classroom instruction (Broda, 2011). The No Child Left Inside© Coalition movement [http://nclicoalition.org] formed in 2007 to politically express the need for more resources and an increased focus on environmental education in America. The No Child Left Inside© Coalition is a "...national coalition of over 2000 business, health, youth, faith, recreational, environmental, and educational groups representing over 50 million Americans (No Child Left Inside©, n.d.)." There are dozens of local No Child Left Inside© Coalition platform is not included. Coalition collaboratives across America [for example, the Miami Valley Collaborative serving Greater Dayton, Ohio] where formal & informal educators as well as partners work together to provide youth with outdoor learning opportunities. The research base supporting the No Child Left Inside© Coalition work is extensive and it involves challenging the "narrowing of the curriculum" in the era of school accountability (Crocco & Costigan, 2007), working to reduce "nature-deficient disorder" (Taylor, Kuo, & Sullivan, 2001), to increase public knowledge about climate change (Lawrence & Saundry, 2008), and to reduce childhood obesity (Jarrett et al., 2013). Due to space limitations separate literature reviews of the components of the No Child Left Inside© Coalition platform is not included.

Context

Thurgood Marshall STEM High School (TMHS) is a state-designated STEM school, which is the only urban STEM school in West-Central Ohio. TMHS is a comprehensive high school serving grades 9 through 12 with a student body of 650 students. The demographics of TMHS include 95% African-Americans, 100% free and reduced lunches, and a special education population of about 25%. TMHS offers Project Lead the Way (PLTW) engineering courses, a math and science club, a STEM Teachers Academy, AP and dual credit courses, and a currently-inactive, award-winning FIRST Robotics Competition (FRC) team. Science fair is an important signature event connected to instruction in all science classes. For several school years, TMHS used a four-block bell schedule with 90-minute periods, which allowed instructors the needed time to use design thinking, inquiry, and outdoor learning. TMHS is situated on the west side of Dayton, Ohio, near local, Ohio prairies at Aullwood Audubon Center and Farm [one of Ohio's largest restored prairies located near Englewood, Ohio]; the Marianist Environmental Education Center (MEEC) [an environmental education community based upon the Marianist, Catholic tradition with a restored 14-acre tallgrass prairie near Beavercreek, Ohio]; and Huffman Prairie [a tallgrass prairie where the Wright Brothers perfected the *Wright Flyer III* on Wright-Patterson Air Force Base (WPAFB), Ohio].

Unit Overview

The prairie garden unit was broken down into three separate learning segments: 1) Background research (Days #1-2); 2) The engineering design challenge of laying out the garden prairie (Days #3-5), 3) Planting the garden prairie (Day #6), and 4) Post-planting learning/reflections (Days #7-8). Senior environmental capstone students first learned about a handful of common native grass prairie species and wildflowers by reading materials provided by our partners at the MEEC and Aullwood Audubon Center & Farm (Day #1). Our partners at the MEEC made suggestions about what species to purchase; these species were the ones students classified on the basis of physical properties. The senior environmental capstone students visited a native grass prairie at Aullwood Audubon Center & Farm before beginning of the engineering design challenge. The engineering design challenge involved using a handful of design criteria and constraints to plan the layout of the garden prairie (NGSS HS-ETS1-3 (National Research Council, 2012); Ohio Technological and Engineering Design Standard #2 (ODE, 2011)). Finally, the prairie garden project helped students learn about prairies by reading the classic environmental text *A Sand County Almanac* by Aldo Leopold followed by an investigation of the natural history of prairies in Ohio. Students learned about how extensive prairies once were in Ohio and how some have been restored (Ohio Environmental Science Standard #2 (ODE, 2011)).

Day One

The pre-project assignment included reading and discussing the National Audubon Society's flyer titled "Ecosystem Adventure Guide: Ohio Prairies." The purpose of reading the flyer was to familiarize students with the idea that native prairies are located in parts of Ohio, but they are not as widely distributed as they once were (Ohio Environmental Science Standard #2 (ODE, 2011)). Our partners from the MEEC met with the team to devise a list of plants to order for the prairie planting. The selected plant species were ones, which were historically native to Ohio prairies. Students were asked to research the plants listed on the school purchase order to learn about each species' scientific name, plant diameter, height, flower color, bloom time, and other notable features (Table #1). The purpose of organizing plant data in table format was to help students obtain easy access to the physical characteristics used to design the layout and placement of plants within the prairie garden plot (Ohio Environmental Science Standard #2 (ODE, 2011)). Students had access to the Internet as well as books provided by the MEEC naturalists. At the end of class, students were briefed about what to wear the next day for a field trip to Aullwood Audubon Center, where they would visit a restored prairie.

	Scientific Name	*Common Name*	*Color*	*Height (cm)*	*Plant Diameter (cm)*	*Other Features (sunlight, wildlife value, rate of spread, etc.)*
1						
2						
3						
4						
5						

Table #1: A data table students used to record native grass prairie species information (modified after Kolstad and Vollerbst, 2011, p. 59).

Day Two

Aullwood Audubon Center, Englewood, Ohio, an affiliate of the National Audubon Society, planted its tall grass prairie in 1959, and it has been used as an educational resource for decades (Moller, 1971). Senior environmental capstone students listened to Aullwood naturalists describe the history of the prairie, and they learned about the natural history of wildflowers and grasses, adaptations of prairie plants for survival, prairie management, food webs in prairies, and what to expect during the prairie planting at Thurgood Marshall STEM High School (Ohio Environmental Science Standards #1 & #2 (ODE, 2011)). Some of the students had previously visited Aullwood during past school years on grant-funded field trips, so many were already familiar with the prairie. After instruction inside the nature center, the students explored the 10-acre prairie with several Aullwood naturalists, exploring the native flora and fauna.

Day Three

Students and teachers used stakes to define the boundaries of the native grass prairie garden with the dimensions of 6.1 meters (20 feet) by 9.1 meters (30 feet). MEEC partners arrived early in the morning with a sod-cutter to remove the weed-filled top soil. Students, teachers, and volunteers rolled up the sod and disposed of it along a wood line behind the school. Hardwood mulch was laid down as a measure to help retain moisture for the soon-to-be planted plugs. The order of plugs was placed with Spence Restoration Nursery (Muncie, Indiana), which was recommended by MEEC naturalists. Spence delivered the plugs, to the high school, where students, with support of MEEC naturalists, sorted them behind the school. Students contemplated how to plant all the plugs in an orderly fashion to view all plants from the outside, provide the sunlight each species required, leave enough space between plants for growth (Equation 1), and have a seasonal balance of flora (Ohio Technological and Engineering Design Standard #2 (ODE, 2011)) (Kolstad & Vollherbst, 2011).

$$\text{Number of Plants Needed} = \frac{\text{Area to Be Planted } (\mathrm{m}^2)}{(\text{Distance Apart})^2 (m^2)} = \frac{A}{D^2}$$

Equation #1: An equation which can be used to calculate how many plants will be needed for a given area (Kolstad & Vollherbst, 2011, p. 57).

Although the planting of a native prairie garden may appear like a science and engineering integrated project (see day #4), Equation #1 requires a level of mathematical thinking about properly placing prairie plants based upon numerical and structural principles (NGSS HS-ETS1- 2 (National Research Council, 2012)). Using Equation #1 to analyze the placement of prairie plants constituted higher levels of STEM integration

Day Four

Engineering design has become an important component of science education and integrative STEM curriculum (National Research Council, 2012). Using NASA's engineering design cycle (Figure #1) and the six design criteria (Table #2), students, in groups, discussed how to systematically plant the prairie garden behind the school. Donald Geiger (Professor Emeritus of Biology at the University of Dayton, MEEC consultant) and Michele Banker (MEEC land manager and consultant) served as the experts on native prairie gardens and biology/ecology while Margaret Gorby (senior environmental capstone teacher) was the instructional expert since she was a classroom teacher. Student groups asked themselves how they could layout the prairie plants in an organized fashion to meet the design *constraints* and *criteria* in Table #2 (HS-ETS1-2 & HS-ETS1-3 (National Research Council, 2012); Technological and Engineering Design Standard #2 (ODE, 2011)). Next, the groups imagined (Step #2) what the prairie would look like once it was planted and grew to its fullest. This was followed by the students designing and planning a scaled prototype design on graph paper (Ohio Technological and Engineering Design Standards Standard #6 (ODE, 2011)) (Step #3). After the student-generated prototypes were laid out, under the guidance of Donald Geiger, Michele Banker, and Margaret Gorby, the students were led through the process of creating new ideas (Step #4) and experimenting with alternate designs (Step #5). Socratic dialogue and back-and-forth questioning helped the groups to improve the prototypes (Step #6). At the end of the 90-minute block, students also began labeling flags, which would be used to identify where each plug would be planted.

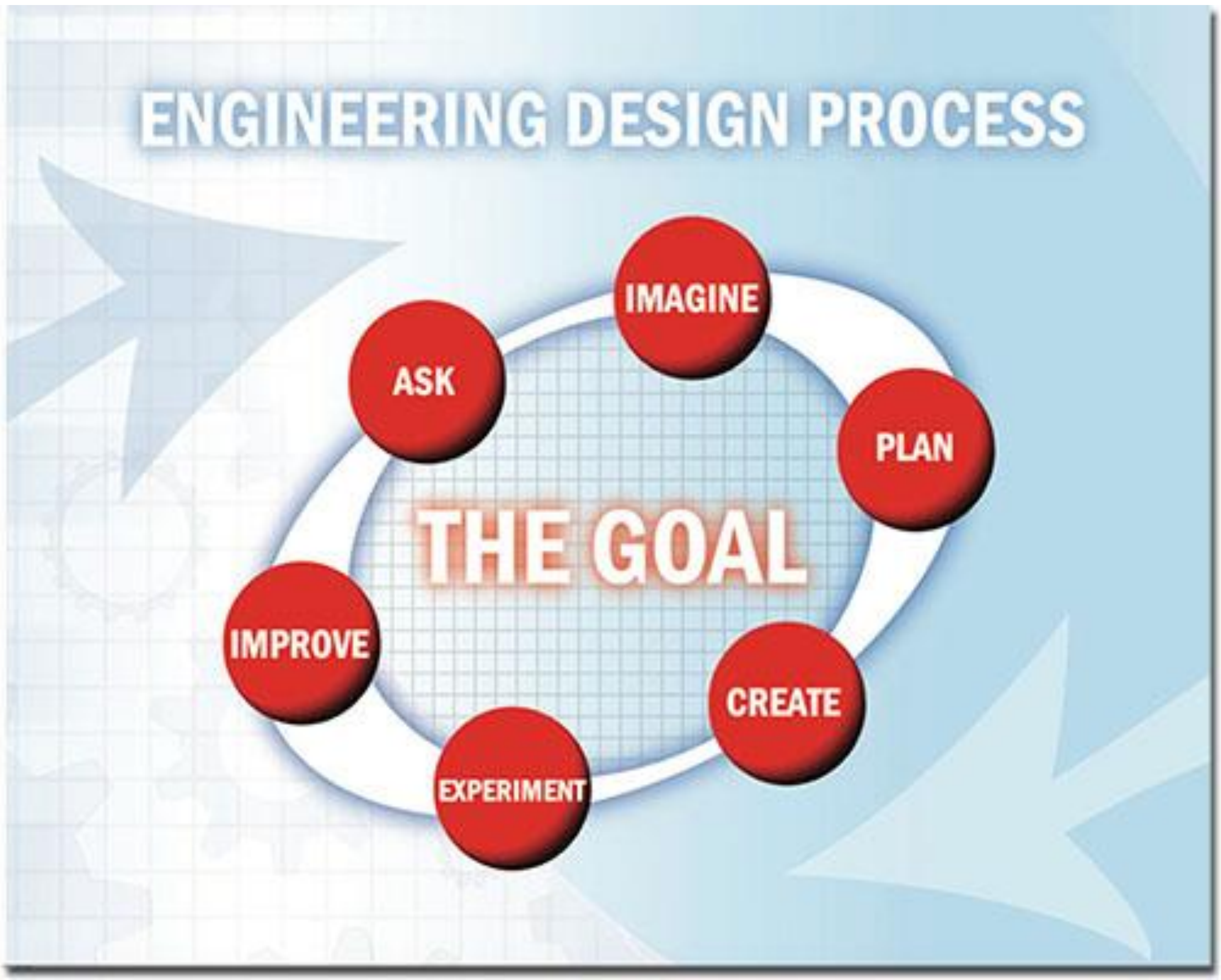

Figure #1: NASA's "BEST Engineering Design Model" with six steps to ask, imagine, plan, create, experiment, and improve (Engineering Design Process, 2018).

Engineering Design Criteria (*For the native prairie garden engineering design challenge*)		
Criteria Number	*Constraint and/or Criteria*	*Needed Information*
Design Criteria #1	The design should be rectangular-shaped with the dimensions of 6.1 m by 9.1 m.	Metric dimensions.
Design Criteria #2	All the plants should be visible from outside of the prairie.	Knowledge of maximum plant height (cm) for each species.
Design Criteria #3	The border of the prairie should be highly visible, so it would not be accidently mowed during the first season.	Knowledge of maximum plant height (cm) for each species.
Design Criteria #4	All the ordered planets should be used in the design, except for a small number, if needed.	Knowledge of the volume of the proposed order from Spence Restoration Nursery.
Design Criteria #5	There should be enough space between the various species to allow appropriate room for growth.	Information about the rate of growth or maximum diameter (in cm) of each species.
Design Criteria #6	The design should be relatively easy to plant in the sense that the species do not excessively alter back and forth.	The total number of species and the dimensions.

Table #2: The six engineering design criteria for the native prairie garden engineering design challenge.

Day Five

The student design challenge, under the guidance of Donald Geiger, Ph.D., Michele Banker, and Margaret Gorby, continued with the aim of each group designing a couple of proto-types; the engineering design criteria are outlined in Table #2. The six design criteria were qualitatively assessed as either "suitable" or "not suitable" through Socratic dialogue between Mrs. Gorby, the MEEC consultants, and the senior environmental capstone students. A more quantitative approach of determining suitability (e.g., decision analysis and weighted factors) would have provided a more scientific method of selecting the most suitable prototype while maximizing student input. The caption for Table #3 provides details about how to use decision analysis and weighted factors to select the best prototype.

Students watched a slide show highlighting each native plant species, which were ordered from Spence Restoration Nursery. The students also referred to the MEEC 2014 Plant Sale brochure and Spence Restoration Nursery catalog to obtain additional information about the native plants. Students worked in small design teams to plan the layout of the prairie on the basis of the six design constraints and criteria (Ohio Technological and Engineering Design Standard #2 (ODE, 2011)) (Table #2). At the end of the class period, the students submitted the prairie garden prototype designs to Mrs. Gorby. After school, Mrs. Gorby worked collaboratively with the MEEC partners to incorporate student design components into a final design. Due to weather-related factors and the school calendar, the date of the planting had to be moved up by days, so the final design, which included multiple student elements was selected by the curriculum team. Unfortunately, students could not go through a fuller iteration of selecting the best prototype through decision analysis [a scientific method of selecting the conceptual design that best fits the objectives]. The short-term weather forecast forced the teacher team to move up the planting of the prairie garden because there was not enough time in the school year to significantly push the planting back. Although the decision analysis process involved student design elements, these features aligned to a plan laid out by the MEEC consultants. Without weather-related changes, the student groups would have had much more time to evaluate, modify, and rate each student prototype by using decision analysis techniques (Ohio Technological and Engineering Design Standard #6 (ODE, 2011; Sivaloganathan & Shahin, 2018; Dym & Little, 2009) (Table #3).

Example Decision Analysis and Weighted Factors Table (Modified after Haik, Sivaloganathan, & Shahin, 2018; Dym & Little, 2009)							
Design Criteria	*Weight*	*Student Design #1* Rank & Value		*Student Design #2* Rank & Value		*Student Design #3* Rank & Value	
#1 Dimensions	6	1	**6**	3	**18**	2	**12**
#2 Visibility	9	1	**9**	2	**18**	3	**27**
#3 Borders	8	2	**16**	1	**8**	3	**24**
#4 Usage	7	3	**21**	2	**14**	1	**7**
#5 Spacing	10	2	**20**	3	**30**	1	**10**
#6 Ease of planting	9	3	**27**	1	**9**	2	**18**
TOTAL SCORE:		**99***		**97**		**98**	
SAMPLE CALCULATION FOR STUDENT DESIGN #1 **TOTAL SCORE = [(6*1)+(9*1)+(8*2)+(7*3)+(10*2)+(9*3)] = 99*** **[the highest score by default is the overall best design to meet the criteria]**							

Table #3 : The first column houses the six design criteria presented in Table #2. In the second column, the "weight" of each design criteria represents how important each one is to the overall project with "10" being very important and "1" representing little/no importance (Pinnell & Blust, n.d.). The next three columns represent three hypothetical student designs (prototypes) which can be ranked by groups or the class as "3" being the best and "1" being the worst (Pinnell & Blust, n.d.). Then, the value for each student design can be calculated by multiplying the "weight" by the "rank" to determine a number value (Pinnell & Blust, n.d.). All of the number values are added up together for each student design to determine the "total score" (Pinnell & Blust, n.d.). A sample calculation is provided to demonstrate how to calculate the "total score" for student design #1.

Day Six

Before school started, a group of teachers and our MEEC partners arrived on site to place the labeled flags into the ground where each plug would be planted. Stormy weather was forecasted for the afternoon, so the plan was to plant the plugs in the early to mid-morning to avoid predicted pop-up thunderstorms. Capstone students, with other, non-capstone student volunteers, helped to plant the plugs based on the final prairie garden prototype design (Figure #2). Thankfully, the entire prairie garden was planted before the stormy weather arrived.

Figure #2: Two MEEC consultants and two students planting the prairie garden behind Thurgood Marshall STEM High School.

Days Seven and Eight

On Day #7, Mrs. Gorby reflected upon the prairie planting project with the senior environmental capstone students. The students discussed the ecological importance of native grass prairies and conversed about the experience of planting a prairie (Ohio Environmental Science Standard #2 (ODE, 2011)). Next, the students in advance were asked to read excerpts of *A Sand County Almanac* by Aldo Leopold, focused upon the portions of the book which describe native grass prairies (Leopold, 1986). Students were given a worksheet to track and reflect upon the major themes highlighted in the excerpts. Mrs. Gorby and capstone students discussed selected themes in the book through class dialogue (Table #4). The purpose of the worksheet was to help scaffold students during class discussions.

Selected Prairie Themes in A Sand County Almanac			
Theme Number	*Description of the Theme*	*Page Numbers*	*Ohio Revised Science Standards for Environmental Science (ODE, 2011)*
Theme #1	Ecological intelligence, “land intelligence,” is something anyone can potentially foster with enough time in nature.	Entire book; “Natural History,” pp. 202-210	
Theme #2	Native prairies were once much more common throughout the Midwest.	“Prairie birthday,” pp. 49-50	E.S. #1 - “Environmental problems and issues” – the environmental effects of growing human populations (ODE, 2011, p. 314)
Theme #3	The public’s understanding of ecology and natural history is low and/or had declined.	“Prairie birthday,” pp. 47-54	
Theme #4	There are still unusual places where native prairies can be found/preserved in the Midwest.	“Prairie birthday,” pp. 47-54	
Theme #5	Conservation is a way of living and life. Conservationists must be ready for action to protect wildlife.	Entire book; “Defenders of Wilderness,” pp. 278-279	
Theme #6	The ecology of any system works in “small cogs and wheels,” much like feedback systems with cause-and effect relationships.	Entire book; “The Round River,” pp. 181-202	E.S. #1 - “Environmental problems and issues” – the environmental effects of growing human populations (ODE, 2011, p. 314)

Table #4: Selected prairie themes in Aldo Leopold’s *A Sand County Almanac* (Leopold, 1986).

Science and Engineering Expectations/Standards

The prairie garden unit covered multiple expectations/standards in the *Next Generation Science Standards* (*NGSS*) (Table #5) and the Ohio Revised Science Standards and Model Curriculum (Table #4), (National Research Council, 2012; ODE, 2011). The student design challenge (see Days #4-5) empowered students to use the principles of engineering design to develop *prototypes* of how to construct the prairie based upon specified *constraints* and *criteria*. The prairie unit covered high school environmental science standards in the ODE Revised Science Standards and Model Curriculum (ODE, 2011). NGSS and ODE expectations/standards have been cited in the most appropriate locations throughout this manuscript.

<u>HS-ETS1 Engineering Design</u> **(*Next Generation Science Standards* (National Research Council, 2012))**	
HS-ETS1 Engineering Design (Performance Expectations)	
Students who demonstrate understanding can:	
HS-ETS1-2.	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be *solved through engineering* [emphasis added] (pp. 49-53).
HS-ETS1-3.	Evaluate a solution to a complex real-world problem based on *prioritized criteria* and *trade-offs* that account for a range of *constraints*, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts [emphases added] (pp. 49-53).
<u>Ohio Technological and Engineering Design Standards (Grades 9-12)</u> **(*Ohio Revised Science Standards and Model Curriculum* (ODE, 2011))**	
Standard #2	Identify a problem or need, consider *design criteria* and *constraints* [emphases added] (p. 11).
Standard #6	Build, test and evaluate a model or *prototype* that solves a problem or a need [emphasis added] (p. 11).

Table #5: NGSS Engineering Design performance expectations (National Research Council, 2012) and Ohio Technological and Engineering Design Standards (ODE, 2011).

Reflections and Discussions

Most of the students were highly engaged with the outdoor learning project (Appendix B). A post-project survey of adults involved in this work (n=4) indicated students were highly engaged in the prairie garden project (average = 4.75, median = 5, Appendix B). The responses to the second survey question suggested the prairie garden project delivered a much above average learning experience for the senior environmental capstone students over traditional classroom instruction (average = 4.75, median = 5, Appendix B). Traditional, standards-centered classroom instruction even with lab work components can sometimes become mundane and unengaging. The change of pace and the engineering design challenge increased engagement and student ownership in the learning process (Administrator #1, Post-Survey). The engineering design challenge also helped to promote student voice and choice in the learning process (Administrator #1, Post-Survey) – both student voice and choice are key constituents of so-called "personalized learning" [an umbrella term for a large number of student-centered pedagogies like project-based learning (PBL)] (Larmer & Mergendoller, 2010). Adult responses to the third survey question demonstrated the engineering design challenge was above average in terms of its overall quality (average = 4.25, median = 4.00, Appendix B). The engineering design challenge could have been more student-driven and analytical in terms of the selection process for the final design, so this is likely the reason why the scores to the third question were lower than the others.

The prairie garden project helped to launch additional outdoor learning opportunities at the high school, including an outdoor classroom, learning spaces, and an urban garden (Teacher #2, Post-Survey). What helped to extend this outdoor learning work beyond the 2013-2014 school year was having a small number of highly-motivated people advocating for curriculum planning time and helping teachers to keep focused upon learning outdoors. People are crucial to sustaining any effort of this magnitude beyond one school year whether they are teachers, administrators, coaches, or community partners. One of the challenges with sustaining any long-term outdoor learning is that these projects are typically driven by one or two people (Administrator #1, Post-Survey). When educators switch jobs or roles, outdoor learning projects may shift or completely go away (Administrator #1, Post-Survey). Each school year starts with new building and district-level school improvement initiatives, so outdoor learning collaboration has the tendency to take a much lower priority to mandates driving teacher accountability (Teacher #1, Post-Survey). Another challenge often encountered is that community stakeholders often possess greater buy-in than a collective teaching staff likely due to time constraints in planning (Teacher #2, Post-Survey).

Limitations

The prairie garden project has several limitations which have influenced how we have chosen to share the work. First of all, the prairie garden project has undergone a single iteration, so the feedback and recommendations we have shared is based upon this experience. After the 2013-2014 school year, four of the six authors eventually moved into new positions either inside or outside of the school district. Next, since the onset of the prairie garden project, we avoided student data collection to remain true to the No Child Left Inside© Coalition's platform that American educators are "over-testing" students. As a result, we do not have student pre-assessment, post-assessment scores, or student interview data to share. Instead we relied upon teacher post-surveys to gauge students' engagement, learning, and the quality of the engineering design challenge (Appendices A & B). Next, due to how we approached the outdoor learning, the state and national standard alignment may not have been tight enough for what curriculum experts may desire. This said, we still contend that the prairie garden project was aligned to Ohio Revised Science Standards and the *NGSS*. We do not have student work samples to share, but we have provided guidance, ideas, recommendations, and resources to help other teams of educators further this work. Finally, we have provided a quantitative method of helping students to analyze a group of prototypes while attempting to balance qualitative and quantitative criteria and constraints (Ohio Technological and Engineering Design Standard #6 (ODE, 2011)) (Table #3) (Haik, Sivaloganathan, & Shahin, 2018; Dym & Little, 2009)). We hope the decision analysis and weighted factors table (Table #3) will help educators to improve upon our qualitative, Socratic method of identifying the best prototype design.

Guidance and Recommendations

Perhaps the most important part of outdoor learning projects is the planning phase which could start one to two years before classroom activities commence (Teacher #3, Post-Survey). In the case of our work, teachers began discussing an outdoor classroom one to two years before the planting of the garden prairie. Advanced planning provides enough time to communicate with external partners like the community park district, the local No Child Left Inside© collaborative, and environmental service organizations. Strong administrative support from principals and the central office is a key component in initiating and sustaining outdoor learning projects (Teacher #3, Post-Survey; Broad, 2011). Administrators have the ability to align building improvement policies, curriculum planning, and vision statements with the goals for the outdoor learning. Principals may also have the ability to leverage common planning periods to help teachers work together during contract time (Teacher #3, Post-Survey). Central office personal may have the ability to procure existing funds (e.g., school improvement dollars) to finance needed equipment and supplies. Communication with administration is also important because it can assist in discussions with the maintenance department, the grounds crew, and facilities management to protect and secure the learning spaces (Teacher #1, Post-Survey). Strong communication, planning time, focus, a common vision, and celebrating accomplishments help to engrain outdoor learning into the school culture and further advance teacher buy-in (Teacher #2, Post-Survey).

Maybe one of the greatest challenges in conducting outdoor learning other than advancing teacher buy-in is securing the funds for needed equipment and supplies (Teacher #3, Post-Survey). Many school districts may not have the necessary budgets to support outdoor learning projects. Local park districts, environmental service organizations, and community foundations may have dollars set aside to help fund outdoor learning projects through competitive selection processes. Central office personnel may have professional contacts with business leaders, or they may serve on local foundation boards. Writing grants could take a significant amount of preparation and time (Miller, 2018), so this must be built into the planning schedule. One of the best places to locate information about foundations and grant making is the Foundation Directory Online [https://fconline.foundationcenter.org/]. Grant writing and management are both outside the scope of this manuscript; however, readers may obtain additional information about science teacher grantmanship by referring to the framework proposed by Miller (2018).

Conclusions

This manuscript told the story of how a building-based curriculum team at Thurgood Marshall STEM High School (Dayton Public Schools, Dayton, Ohio) collaborated with environmental partners to develop an outdoor learning unit about native grass prairies. A group of senior environmental capstone students learned about native grass prairies, visited a prairie at Aullwood Audubon Center & Farm, participated in an engineering design challenge to develop a garden prairie based upon specific criteria, selected the best design, planted the prairie garden, and then connected learning to a classic environmental text. This article described the timeline of the project from day #1 through day # 8 including details about the engineering design challenge. The prairie garden project, during its initial year and only year, was deemed a success as the result of engaging and interactive outdoor learning as gauged by teacher post-surveys (Prairie Garden Project Team Post-Survey, Appendixes A & B). Student engagement was determined higher than traditional instruction (Prairie Garden Project Team Post-Survey, Appendixes A & B). This article ended by providing teachers and curriculum teams with guidance, ideas, recommendations, and resources to initiate similar or more focused types of outdoor learning projects based upon advanced planning, internal/external funding, teacher buy-in, and communication/support with administration (Appendixes C, D, & E). Building upon these successes, the plan at Thurgood Marshall STEM High School is to continue connecting environmental outdoor learning experiences to core subjects beyond science, including English language arts, mathematics, and social studies, which will help to expand environmental, outdoor learning for students at the high school.

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APPENDIX A:

Prairie Garden Project Team Post-Survey

1. How would you rate the engagement of the senior environmental capstone students working on the prairie garden project? (CIRCLE ONE CHOICE)

Highly-engaged   Engaged   Moderately engaged   Unengaged   Very unengaged

2. How would you rate the overall student learning experiences?* (CIRCLE ONE CHOICE)

Much above average   Above average   Average   Below average   Very below average

3. How would you rate the quality of the engineering design challenge within the unit (see Table #2)? (CIRCLE ONE VHOICE)

Much above average   Above average   Average   Below average   Very below average

4. How do you think this senior environmental capstone project impacted/influenced the trajectory of outdoor learning at Thurgood Marshall STEM High School? Please explain.

5a. How would you describe the partnership between Thurgood Marshall STEM High School and Aullwood Audubon Center & Farm? Please explain.

5b. How do you think Aullwood Audubon Center & Farm helped the school to accomplish the senior environmental capstone project? Please explain.

6a. How would you describe the partnership between Thurgood Marshall STEM High School and the Marianist Environmental Education Center (MEEC)? Please explain.

6b. How do you think the Marianist Environmental Education Center (MEEC) helped the school to accomplish the senior environmental capstone project? Please explain.

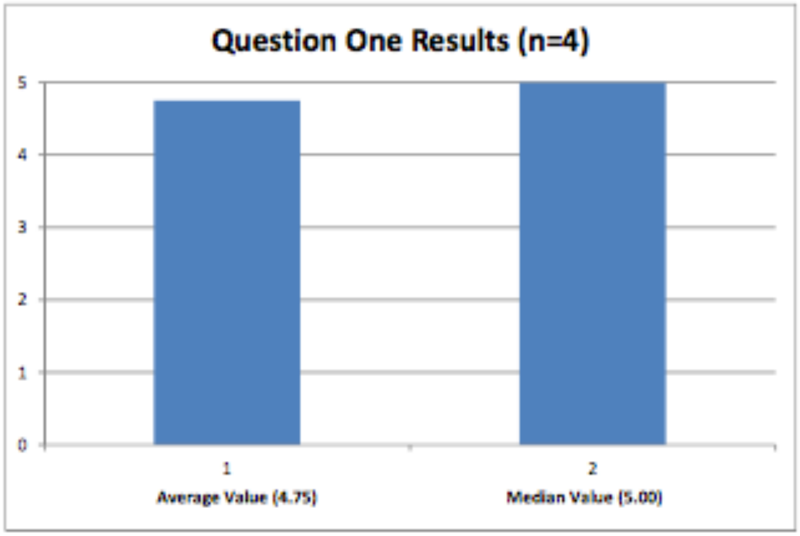
7. What did the students find the most challenging about the prairie garden project? Please explain.

8. What did the students find most enjoyable about the prairie garden project? Please explain.

9. Why do you think projects of this magnitude and nature are difficult to sustain? Explain.

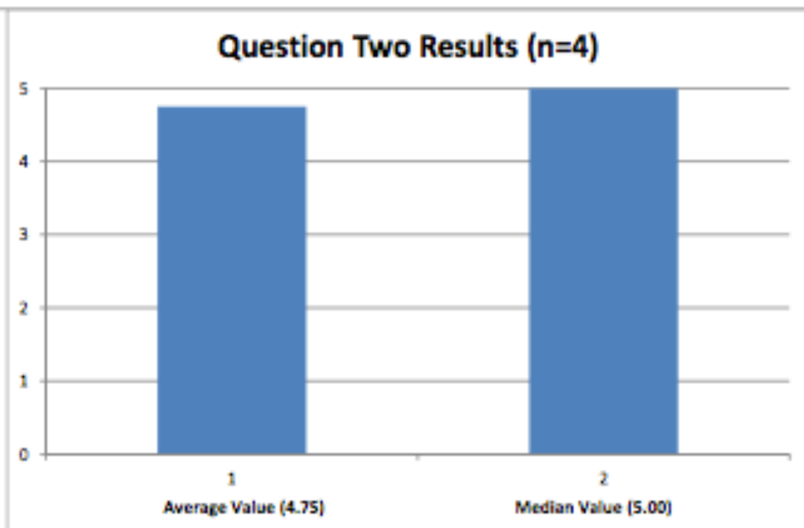
APPENDIX B:

Data from the Prairie Garden Project Team Post-Survey



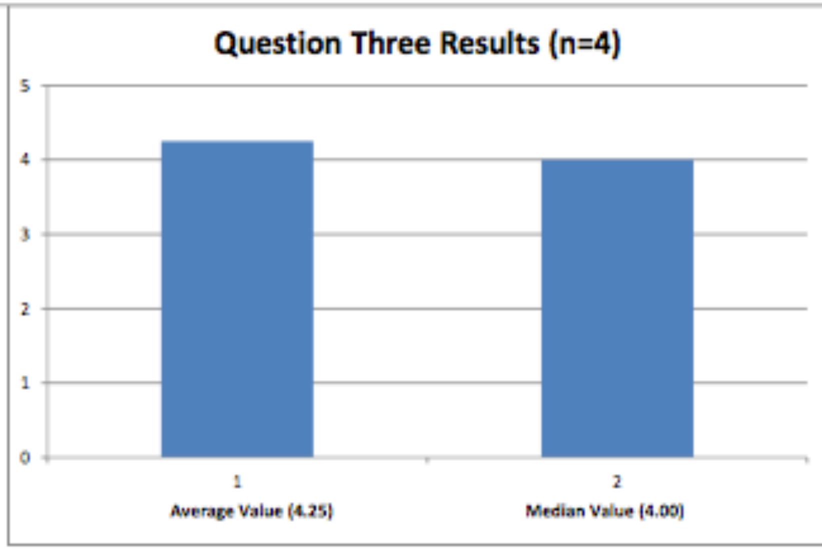
How would you rate the engagement of the senior environmental capstone students working on the prairie garden project?

Highly-engaged	Engaged	Moderately engaged	Unengaged	Very unengaged
5	4	3	2	1



How would you rate the overall student learning experiences?

Much above average	Above average	Average learning	Below average	Very below average
5	4	3	2	1



How would you rate the quality of the engineering design challenge within the unit (see Table #2 [in the survey])?)

Much above average	Above average	Average	Below average	Very below average
5	4	3	2	1

APPENDIX C:

Recommended Books on Prairies

Adelman, C. & Schwartz, B. (2013). *Prairie directory of North America: The United States, Canada, and Mexico*. New York, NY: Oxford University Press.

Manning, R. (1997). *Grassland: The history, biology, politics and promise of the American prairie*. New York, NY: Penguin Books.

Savage, C. (2011). *Prairie: A natural history*. Berkeley, CA: D & M Publishers, Inc.

Steiner, L. (2010). *Prairie-style gardens: Capturing the essence of the American prairie wherever you live*. Portland, OR: Timber Press.

APPENDIX D:

Recommended Web Sites on Prairies

1) Aullwood Audubon Center and Farm, one of Ohio's largest restored prairies (Englewood, Ohio): http://aullwood.audubon.org/

2) Huffman Prairie Flying Field, where the Wright Brother's perfected the Wright Flyer III (Wright-Patterson AFB, Ohio):

- Five River's Metro Park: https://www.metroparks.org/wp-content/uploads/2016/05/metroparks-huffman-prairie-brochure-2015.pdf
- National Park Service: https://www.nps.gov/daav/learn/historyculture/huffman-prairie-flying-field.htm
- Smithsonian Air and Space Museum: https://airandspace.si.edu/exhibitions/wright-brothers/online/fly/1904/huffman.cfm

3) Indiana Department of Natural Resources (IDNR) (Indiana Prairies): https://www.in.gov/dnr/naturepreserve/4739.htm

4) Marianist Environmental Educational Center (MEEC) (Beavercreek, Ohio): https://meec.center/

5) Ohio Department of Natural Resources (ODNR) (Ohio Prairies): http://naturepreserves.ohiodnr.gov/natural-areas-preserves-home/post/ohio-s-tall-grass-prairies

6) Ohio Prairie Association: http://www.ohioprairie.org/

7) Spence Restoration Nursery (Muncie, Indiana): http://www.spencenursery.com/Index/home.php

APPENDIX E:

Recommended Books on Prairie Gardens, Native Landscaping, and School Green Spaces

Bloom, M. A., Holden, M., Sawey, A. T., & Weinburgh, M. H. (2010). Promoting the use of outdoor learning spaces by K-12 inservice science teachers through an outdoor professional development experience. In *The inclusion of environmental education in science teacher education* (pp. 97-110). Springer, Dordrecht.

Broda, H. W. (2011). *Moving the classroom outdoors: Schoolyard-enhanced learning in action*. Portsmouth, NH: Stenhouse Publishers.

Grant, T., & Littlejohn, G. (2001). *Greening school grounds: Creating habitats for learning*. Lewiston, NY: Green Teacher.

Miller, W. (2002). *The prairie spirit in landscape gardening*. Amherst, MA: University of Massachusetts Press.

Robinson, W. (2009). *The wild garden: Expanded edition*. Portland, OR: Timber Press, Inc.

Steiner, L. M. (2010). *Prairie-style gardens: Capturing the essence of the American prairie wherever you live*. Portland, OR: Timber Press, Inc.

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